

ECOLOGY AND BEHAVIOUR OF THE PIG-TAILED MACAQUE *MACACA NEMESTRINA LEONINA* IN SOME FORESTS OF ASSAM IN NORTH-EAST INDIA

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The Northern Pig-tailed Macaque *Macaca nemestrina leonina* is among the poorly studied primates of South-east Asia. Its ecology and behaviour in some rainforest pockets of Assam in north-eastern India are presented and discussed here. The study period extended between 1986 and 2006, but detailed observations were carried out during 1992-94 and in 2004 with 290 hours of direct contact. This dense forest-dwelling macaque is largely arboreal. Resting including roosting accounted for about 45% of their diurnal time. Feeding activity followed with 23.5%. Locomotion is a major activity accounting for 17 to 19.4% of their diurnal time. The Pig-tailed Macaque's diet included 65.9% fruits. During feeding, occasionally a group may split into two subgroups for a short period. They live in multi-male and multi-female groups. The group size ranged from 16 to 33. The sex ratio of the adults was 1:5.5. Interactions within group members and with other groups were largely peaceful. The home ranges were between 83 and 347 ha and the overlapping was 25 to 48%. The range length in a day varied between 690 and 2,240 m. Estrous females were observed from August to February. Newborns were observed from mid-January to early May. Females copulated with several males. The time taken for each mounting bout ranged from 2 to 16 seconds and the number of thrusts given by the male partner ranged from 3 to 23. The inter bout gap was 1 to 65 min. After copulation bouts, the male usually uttered a low bark. The female normally groomed the male after a copulation bout. The male remained completely lifted while copulating as his legs held those of the female. The gestation period was estimated to be 171-180 days.

Key words: *Macaca nemestrina leonina*, Northern Pig-tailed Macaque, Assam, ecology, social behaviour, feeding, ranging, reproduction

INTRODUCTION

The Pig-tailed Macaque *Macaca nemestrina* Linnaeus, 1766 is among the poorly studied primates of South-east Asia. Because of their elusiveness and furtive behaviour in the wild, their ecology and social behaviour are difficult to study (Bernstein 1967; Caldecott 1986). It is widely distributed throughout South-east Asia – in north-east India, south-west China, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaya, Mergui Archipelago, Sumatra, Bangka Island, Pagai Island, Mentawai Islands and Borneo (Napier and Napier 1967; Yin 1967; Eudey 1987; Groves 1993, 2001; Le Xuan Canh *et al.* 1997; Duckworth *et al.* 1999; Choudhury 2003a).

In India, its distribution is restricted to the south of the Brahmaputra river where it occurs in all the states (Choudhury 1988a, 1989, 2003a). Anon (1997) had erroneously reported its occurrence to the north of the Brahmaputra. The Northern Pig-tailed Macaque is found in the forests, both in the plains and hills up to 2,000 m elevation (Choudhury 2003a). For quite a long period, the distribution of *leonina* in India was imperfectly known and vaguely referred to "eastern India (probably some districts east of the Ganges)" (Pocock 1939), and "Assam" (Roonwal and Mohnot 1977). Corbet and Hill (1992) did not include north-east India as well as Bangladesh within the range of this species although its occurrence has been mentioned in Ellerman and Morrison-Scott (1951), Choudhury (1988a, 1989, 1995a) and Khan (1981).

The subspecies found in north-east India is *leonina* (Fooden 1975). The subspecies *M.n. blythii* Pocock, 1931: 305, has been synonymised with *leonina* by Fooden (1975). Groves (2001) proposed full specific treatment for this subspecies.

Till the mid 1980s, the scanty literature available for *leonina* was restricted to publications by Pocock (1931, 1939, 1941) and McCann (1933). General information is also found in Blanford (1888-91), Finn (1929), Prater (1948), Ellerman and Morrison-Scott (1951), Gust *et al.* (1996), Napier and Napier (1967), and Roonwal and Mohnot (1977). Some studies were carried out since then in north-eastern India (Mukherjee 1982; Tilson 1982; Choudhury 1983, 1988a,b, 1989, 1995a,b, 1996a,b, 2001, 2002, 2003a,b), and in Bangladesh (Feeroz *et al.* 1994). A comprehensive account on its distribution and status in India is found in Choudhury (2003a) while its range in the region has also been mapped in detail by Choudhury (2003a,b). Elsewhere, the taxonomy and evolution of *M. nemestrina* have been reviewed by Fooden (1975). The Southern Pig-tailed Macaque *M. nemestrina nemestrina*, on the other hand, is relatively better studied in the field in Malaya (McClure 1964; Bernstein 1967, 1969; Medway 1969) and Sumatra (Oi 1990). Some other noteworthy publications are those of Crockett and Wilson (1980) and Caldecott (1986).

The ecology and behaviour of the Northern Pig-tailed Macaque as observed in the field are presented here in this paper.

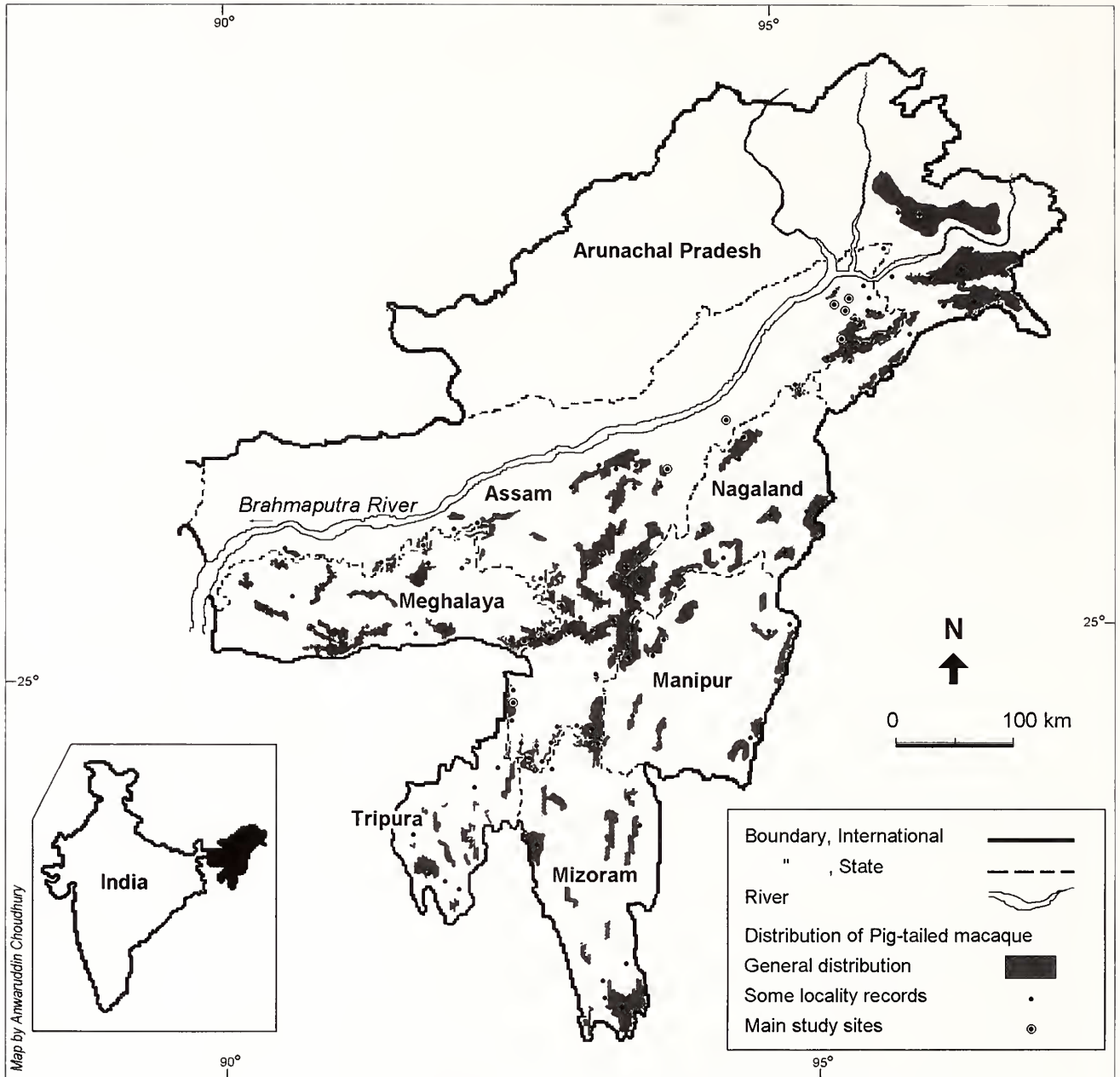


Fig. 1: Map showing the distribution of the Pig-tailed Macaque and the main study sites

METHODS

Study area

Although the general survey covered the north-eastern India, which comprises the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura (21° 58'-29° 27' N; 89° 42'-97° 24' E), the main observations were made in some forests of Assam (Fig. 1). The location, topography, vegetation and climate of these areas are given in Table 1.

Between February 1986 and May 2006, I was able to carry out field surveys in some potential habitats of the

Northern Pig-tailed Macaque in north-east India as a part of a broader survey of wildlife. During 1992-94 and in 2004, I carried out some detailed observations on Northern Pig-tailed Macaque. While travelling widely in Assam, Arunachal Pradesh, Meghalaya, and Mizoram, I also visited Nagaland, Manipur, and Tripura. In July 2006, I made a brief visit to Thailand to observe the macaques for comparison of their external characters and human imprint.

Field procedures

During field study, the presence or absence of the macaque was ascertained by direct sighting, preserved skulls

in the tribal villages, and by interviewing local forest staff, villagers and hunters with the help of visuals (photos and drawings). Some of the skulls were identified at the Zoological Survey of India, Kolkata. For direct observation, foot-transects and elephant-transects (using trained elephants) along existing paths, newly cut paths and trails, vehicle-transects along roads and motorable tracks, boat-transects along *nullahs* and rivers were made. Total 290 hrs were spent in direct observation of the macaques (133 hrs in Bherjan, 40 hrs in Borajan, 31 hrs in Nambor-Garampani, 20 hrs in Podumoni, 13 hrs in Upper Dihing west block and 53 hrs elsewhere). Dense vegetation and elusiveness of the macaques were the main constraints in the field (for e.g., total time spent in a tiny forest such as Bherjan with 105.5 ha was 360 hrs; however, the macaques were in direct contact for only 133 hrs).

Detailed observations were made in select localities depending upon visibility, relative abundance and less shyness of the macaques. Daily activity budget was recorded by scan sampling at intervals of 5 mins (against 10 min interval of Martin and Bateson 1993) for greater details; however, any interesting behaviour and changes in activity in between was also recorded, from dawn to dusk. The home ranges were calculated from 1:50,000 scale maps enlarged photographically to about 1:20,000. All the sighting localities of a particular group observed at different times of the year were plotted on the map. The daily range is the distance

covered by a group during its daily activity patterns while the home range was determined here by closed traverse made by joining the outermost traces of movement of a group during the period of observation (more than a year in the groups considered here). A closed traverse (polygon), made up of all the sites, was considered as the home range. The area of the home ranges was calculated by superimposing a scaled grid (1.25 ha per grid). The daily range was calculated by measuring the ground distance covered by a group from morning to evening. The data on food items were collected across groups and study areas, and not necessarily confined to the study groups. The proportion of feeding on fruits and other items was calculated on the basis of time spent on feeding on those items. Herbarium sheets were prepared for the food species, which could not be identified in the field. These were then identified at the Botanical Survey of India, Shillong. The book by Kanjilal *et al.* (1938) also helped identify some of the common species. For analysing the species diversity of vegetarian food items (Fig. 3b), a tree species providing two types of food items such as leaf and fruit, has been counted twice, once each under the category 'leaf' and 'fruit' to have a logical visual presentation in a diagram. Observations were done with the help of naked eye, a pair of binoculars, a 10 x 50 telescope and a 10 x 46 monocular. Photographs were taken with a Canon T50 camera with 200 mm tele and a Nikon FM2.

Table 1: Detailed features of the field study sites

| Name of the area | Coordinates | Topography with elevation | Forest type | Rainfall | Temperature (°C) |
|------------------------------|------------------------------|--|--|------------|------------------|
| Hollongapar Gibbon Sanctuary | (26°45' N, 94°25' E) | Plains; 100-110 m | Tropical wet semi-evergreen or rainforest | > 2,000 mm | 7-35 |
| Bherjan-Borajan-Podumoni WS | (27°25'-32' N, 95°19'-23' E) | Plains; 110-130 m | Tropical wet evergreen or rainforest and deciduous plantations | > 2,300 mm | 7-35 |
| Upper Dihing (west block) RF | (27°20' N, 95°30' E) | Plains and low undulating country, 100-200 m | Tropical wet evergreen or rainforest | > 2,300 mm | 7-35 |
| Garampani and Nambor WS | (26°23' N, 93°52' E) | Low undulating country, 170-250 m | Tropical wet semi-evergreen or rainforest | > 1,800 mm | 7-35 |
| Patharia Hill RF | (24°40' N, 92°15' E) | Low hilly, 20-150 m | Tropical wet evergreen or rainforest with degradation | > 3,000 mm | 7-35 |

RF=reserved forest; WL=wildlife sanctuary

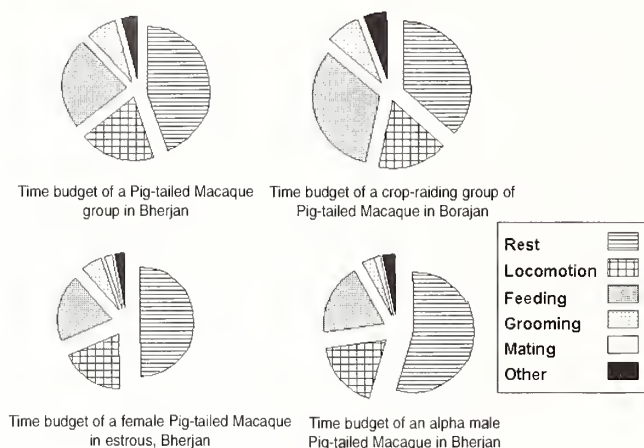


Fig. 2: Daily activity patterns in Pig-tailed Macaques

RESULTS

The Northern Pig-tailed Macaque is among the most arboreal of the macaques found in north-east India. They come down to the ground for crossing clearings and also for foraging, especially in degraded areas. Of the total 133 hrs of observation in Bherjan, the macaques were observed for only 120 mins on the ground (mostly lone males; once a female with infant, and two immatures). The group may not come to the ground at all for many days in forests with relatively good canopy cover (e.g., Bherjan). However, in the nearby Borajan, where the canopy was broken, the macaques were frequently observed on the ground, crossing roads and clear-felled patches.

Daily activity pattern

Northern Pig-tailed Macaques become active just after dawn. The daily time budget of two groups in Bherjan showed an activity pattern with three peaks of feeding, and a long midday rest. There was a shorter spell of resting around mid-morning and late afternoon. In winter, most macaques went for basking in sun, and the mid-morning rest was often utilised for this activity. Resting including roosting (till dusk) accounted for about 45% of their diurnal time; feeding activity followed with 23.5%. In August, in Bherjan forests, three important feeding periods were from 0610 to 0640 hrs, 0900 to 0940 hrs and again from 1230 to 1400 hrs. In January in Borajan forests, the three important feeding periods of the crop-raiding group were from 0615 to 0650 hrs (in forest), 0800 to 0950 hrs and again from 1225 to 1405 hrs (both in the harvested paddy field).

The copulating alpha male of the Eastern Group in Bherjan spent as much as 54.4% of the diurnal time in resting and 19% feeding. During mating time, the alpha male and an

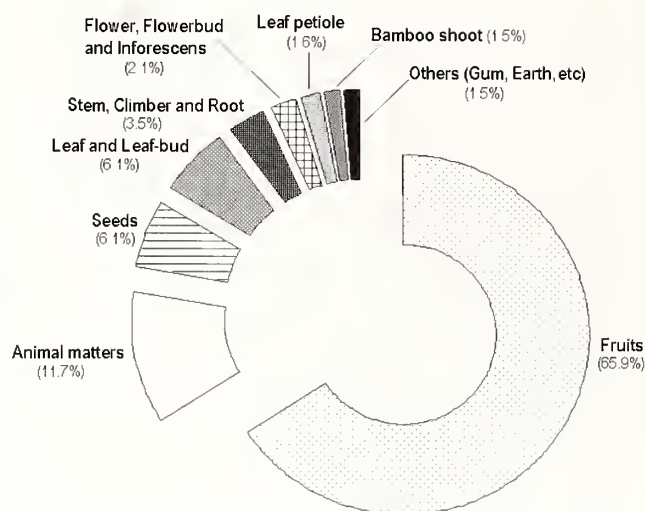


Fig. 3a: Proportion of food items of Pig-tailed Macaque

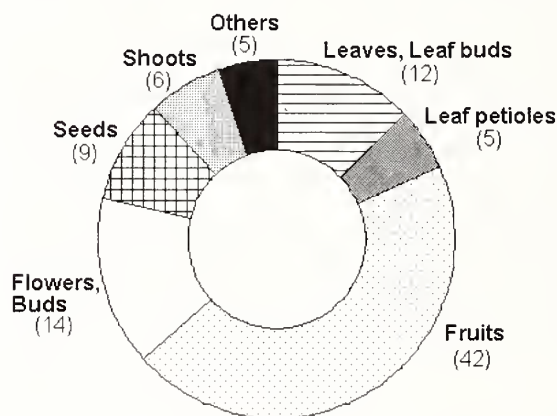


Fig. 3b: Species diversity of sources of vegetarian food item

estrous females respectively spent as much as 33.7% and 56.5% in copulation, and its related activities such as post-copulation grooming and resting between repeated copulations. It was more in case of the female as two males had copulated with it (Fig. 2).

Locomotion

Northern Pig-tailed Macaques were observed using both arboreal and terrestrial paths. They travel quadrupedally both on the ground and through trees. Occasionally they stand up on their hind legs to see any intruder. The crop raiding groups at Borajan forests were observed doing so while feeding on the ground. In closed canopy forest, they usually travel through trees leaping or jumping when the distance is not within reach, and walking on all fours on tree trunks. In broken habitat, they did not hesitate to come down to the ground and walked across. They jumped from tree to tree, bending and breaking branches under their weight. The groups

usually travel in single-file through trees, shrubs or bamboos, and each individual may pass along the same route or the same branches as the preceding ones (observed repeatedly in Bherjan forests). In the Western Group at Bherjan, the alpha male moved first followed by juveniles, subadults, other adults and lastly the females with infants. They communicate by uttering *pno*, *pno*, etc., while travelling. They may also travel in small subgroups, foraging as they move and keeping in contact with other subgroups through vocalizations *pno*, *po*.

Locomotion in Northern Pig-tailed Macaques accounted for 17 to 19.4% of their diurnal time (feeding and resting for short stints during locomotion have been included in those activities).

Food and feeding

Northern Pig-tailed Macaques were observed feeding on fruits, seeds, mature and tender leaves, leaf buds, leaf petioles, stems, climbers, roots, flowers, flower-buds, inflorescence, bamboo shoots, as well as gums, insects and larvae, termite eggs and spiders. They also take some earth occasionally (may be for minerals). At a few places, they raid crops for grain, fruits and vegetables. The dominance of fruits in its diet was very conspicuous whether it is number of species involved or the time spent on it. In the study groups of Bherjan forests, fruit comprised 65.9% of the macaque’s diet (Fig. 3a). The Northern Pig-tailed Macaque eats more than 91 kinds of plants, many of which could not be identified. The different types of fruits, flowers and other items are shown in Fig. 3b. Appendix 1 lists the plant species with parts eaten.

Fruits were eaten either partially (e.g., *Lagerstroemia flosreginae*, *Artocarpus chaplasha*) or wholly (e.g., *Sapinum baccatum*). In case of latter, they usually break the twigs with a large number of fruits (bunches) and actually consuming partially, thus wasting many. Flowers were eaten completely

but in some cases only selected parts were consumed. It also licked from the branches for insects and larvae. Insects were also picked up from leaves and spider’s web. Spiders were taken both from tree branches as well as webs. The only root taken was that of an epiphytic orchid while the tender tops of two unidentified climbers were also taken. Northern Pig-tailed Macaques feed on small leaves and figs by pulling branches towards them, and then plucking them directly off the branches. To remove a number of smaller leaves at a time, the macaque holds the twig in one hand, and with a single sweep of the other hand, takes off all the leaves. Larger leaves, fruits and flowers are pulled off the branches with either of the hands, and then eaten. Often the macaques were seen carrying a twig with fruits and taken to a comfortable branch for feeding. During feeding, occasionally a group may split into two subgroups for a short period. It spends nearly one fourth of the diurnal time in feeding (23.5% in August). A group in Borajan spent 32.9% of their diurnal time on feeding, mostly in the harvested paddy fields. The feeding time ranged from 158 to 229 minutes in a day. It has three peaks of feeding (for details of feeding periods, see ‘daily activity pattern’).

While feeding, the members of a group were loosely dispersed over a sizeable area and were observed to even split up into two subgroups. The maximum distance observed between two extreme individuals of foraging subgroup was about 150 m (Bherjan forests, August 21, 1992).

Social organization

Northern Pig-tailed Macaques have a multimale-multifemale social system. The normal group size varied from 16 to 33 (n=7). These were the groups where exact counting was possible and were repeatedly counted for several days. In most cases, exact counting was difficult due to dense forest.

Table 2: Group size and composition in Pig-tailed macaque

| | | Adult Male | Adult Female | Adolescent Male | Adolescent Female | Juvenile | Infant | Total | Remarks |
|----------------|--------------|------------|--------------|-----------------|-------------------|----------|--------|-------|----------------|
| February 1992 | Garampani WS | 2 | 15 | 1 | 4 | 6 | 5 | 33 | |
| February 1992 | Nambor WS | 2 | 11 | 1 | 4 | 7 | 1 | 26 | |
| January 1993 | Borajan RF | 1 | 12 | 1 | 4 | 6 | | 24 | Northern Group |
| January 1993 | Borajan RF | 1 | 10 | 1 | 3 | 5 | 1 | 21 | Southern Group |
| July-Aug. 1992 | Bherjan RF | 2 | 7 | 1 | 1 | 3 | 6 | 20 | Western Group |
| July-Aug. 1992 | Bherjan RF | 3 | 5 | 2 | 4 | 7 | 2 | 23 | Eastern Group |
| January 1993 | Podumoni RF | 1 | 6 | 1 | 2 | 3 | 3 | 16 | |
| | Mean | 1.7 | 9.4 | 1.1 | 3.1 | 5.3 | 2.6 | 23.3 | |
| | Range | 1-3 | 5-15 | 1-2 | 1-4 | 3-7 | 1-6 | 16-33 | |
| | % | 7.4 | 40.5 | 4.9 | 13.5 | 22.7 | 11.0 | 100 | |

NB: At least another 15 groups in Innerline RF, Dhansiri RF, Upper Dihing (west block) RF, Dum Duma RF, Kumsong RF and Patharia Hill RF were recorded to have 20+ macaques but details are lacking

Hence, only seven groups were considered although partial count was possible for another six while many sightings were recorded when only partial count was possible. Single adult males have also been encountered in the forest. Table 2 lists the group size and composition of some troops where count / estimate were possible. The mean of seven groups was 23.3. In at least another 15 groups, the size was >20.

Six smaller groups were also encountered with size varying from 5 to 12 with a mean of 7.2 (Table 2), but detailed observation of 22 groups indicated that these were in all probability subgroups, formed temporarily for foraging. The proportion of adult females was 40.5% against 7.4% males. The sex ratio of the adults was 1:5.5.

Social behaviour

(i) Mother-infant relationship: Mother-infant relationship in Northern Pig-tailed Macaques is intimate. Mothers protect their infants from other group members and sympatric species. Until it is about a month old, the mother rarely broke contact with the infant. Then the infant began to leave the mother and explore the surroundings within a metre or so. The infant began to move out 2-4 m away by about 2 months of age. The infant also started foraging, however, still maintaining close contact with the mother. When about a year old, the infant (could be termed as juvenile) spent most of the time moving along with the group, only to return to its mother during resting and night roosting. Infant grooming by mother was common, especially during the midday resting period. The infant's vocalisation consisted mostly of squealing and screaming, usually when left alone by mother or inadvertently threatened by an adult or subadult. Adult males were observed to be rather indifferent to the infants.

(ii) Play: Play behaviour was observed mostly in infants and juveniles, and only occasionally in subadults. They indulged in play during morning resting, and during and after the midday resting period. Infants sometimes played with their mother. Friendly wrestling bouts among juveniles and subadults and short-distance chases were among the common plays. Some subadult and juveniles also mock mate as a part of play. The younger macaques spent maximum time of their total social behaviour in play. Infants and juveniles were observed to spend more time playing followed by subadults. Virtually no play was observed among the adults. Self-play was also observed among the juveniles and infants. Once a subadult female teased an infant by touching it and making frightening gesture, the infant screamed. The mother then chased the subadult.

(iii) Agonistic behaviour: This occurred infrequently and usually involved momentary squabbles over food between adult females, subadult males or both. However, aggressive

threats and chasing of adult and subadult males by the alpha male was observed, especially when any female was in estrous. The other males were observed to submit without actually coming into conflict. No rigid dominance hierarchy was observed among the adult females of a group.

(iv) Grooming: Grooming was one of the major activities of social behaviour, with each grooming bout lasting from a few seconds to more than 60 mins, which forms nearly 6 to 8% of the total activity period. Males busy in copulation groomed less (3.5% of the total activity period). Grooming was usually done with one or both hands. Grooming took place between individuals of all age/sex classes, except infants who mostly received. During grooming, extraneous matters were removed by hands or with the mouth. The groomed individual sits relaxed often with the eyes closed. After mating, the female usually groomed the male. Grooming, except when performed after mating, was usually done during the midday resting period and late in the afternoon. Self grooming of tail, abdomen, limbs and genital portions (by male only) were also observed. The estrous females were groomed in their genital portion by adult males. Scratching of the body was done with hands and feet.

(v) Interaction within group members: Adult males were dominant over adult females while in the multimale groups, the alpha male was dominant over other males. Although in multiple male groups, the males coexisted peacefully, there was a linear dominance hierarchy, which was conspicuous in a group during sexual cycle. After an alpha male completed its copulation bouts and left for resting a little distance away, the second male came and copulated several times. Then a third adult male approached only to be chased away by the second male. On a few occasions, subadult males were seen copulating when the adult males were not around. The second adult male of Eastern Group in Bherjan once observed mock mounting the alpha male after latter stared at him following his copulation with a female in estrous. On a few occasions, the alpha male had copulation bouts when the second male was sitting close by (only a metre away).

Two infants, which were carried by their mothers, but which also foraged (less than a year old) had begged two adult females (not their mothers) for *Anthocephalus cadamba* fruits. The adults complied with, then both the infants left with fruits in their hand (Bherjan forests; July 30, 1992). Juveniles often curiously observed copulation bouts.

(vi) Interaction with other groups: On the whole, relations between Northern Pig-tailed Macaque groups were peaceful and actual fights were not seen. Two groups peacefully feeding within 60 to 100 m have been observed repeatedly in Bherjan and Borajan. In fact, their respective home ranges overlapped in the study sites. However,

occasional exchange of visual and vocal displays with chasing, usually by subordinate males, took place. Shaking of tree branches by the adult males was also observed. Two groups were observed on many occasions foraging and even copulating within 60 m with no agonism.

(vii) Interactions between groups and solitary male:

Direct interaction between a solitary male and a troop was observed only once in Nambor Wildlife Sanctuary on March 02, 1992. A solitary male had approached a group feeding on sugarcane near the highway, when two adults, a male (not the alpha) and a female chased it to a tree with less foliage. Then they forced it to move to another tree with dense foliage while they remained in the tree with less foliage. When the solitary male again tried to come to the tree with less foliage, they again chased him by jumping to the tree with foliage. That time the solitary male had to flee from the scene. While chasing, the male was ahead of the female. Then the female groomed the male for about 3 mins in the tree with foliage. The pair was also observed copulating. After about 10 mins, the alpha male among the group that was feeding on sugarcane near the highway was silent when the earlier confrontation took place growled *hrrr-hrrr* and rushed towards the couple/site of confrontation. The macaques were not visible due to dense vegetation and further developments could not be observed. At about 1600 hrs, the lone male was visible but at about 400 m away from the main group, and was moving about on the ground.

Reproduction and sexual behaviour

In Bherjan forests, several females in estrous were observed from August to early December, and in Nambor till February.

When the female was ready to mate, the hairless area of her buttocks swelled up and turned red. During that period, copulation was a major activity for the adult males and females in estrous. Newborns were observed from mid-January to early May. The Northern Pig-tailed Macaque gave birth to a single offspring. For copulation, females were observed soliciting males by presenting their rump after approaching them from behind and standing in front of males mostly without any hint. On a few occasions the males were seen touching the rump of sitting or foraging females when the latter stood up and presented often looking back over one shoulder. Sometimes the female may run away also. Once after nine copulation bouts, the female ran away but the male followed it and mounted for another nine bouts.

A female was observed copulating with two adult males of the group, one in the forenoon another in the afternoon. With first (alpha male), she had seven copulations while with the second nine. A third male also tried to copulate but was

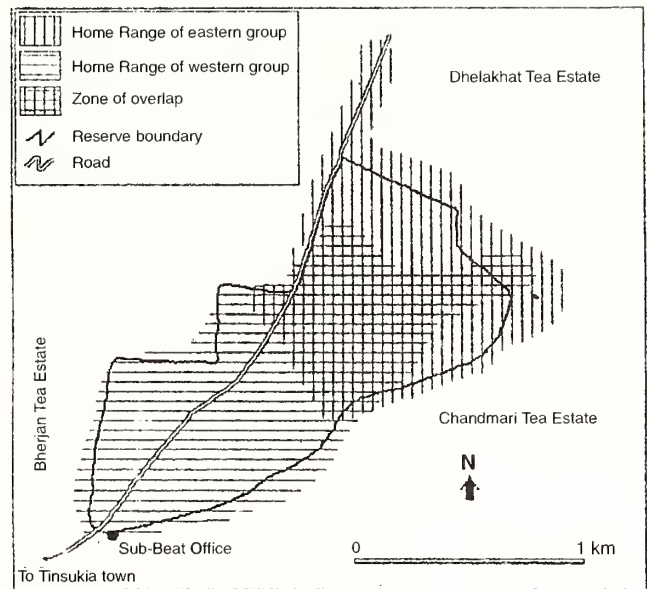


Fig. 4: Map of Bherjan forests and adjacent areas showing the home range of two Pig-tailed Macaque groups

chased away by the 2nd. However, on another day, a subadult took the opportunity of absence of adult males and copulated. It has been recorded that the copulations took place between 0700 hrs and 1440hrs in Bherjan forests. The time taken for each mounting bout ranged from 2 to 16 seconds and the number of thrusts given by the male partner ranged from 3 to 23. A female was observed having copulation bouts for 20 days (from November 10 to 30, 1992; Bherjan forests).

In the Eastern Group in Bherjan, the alpha male was observed having seven mounting bouts in the forenoon within 2 hr 23 mins. In between, once he refused to mount although insisted by the female. In the afternoon, the 2nd male copulated taking the advantage of absence of the alpha male, which was resting some distance away. It had nine bouts within a time span of just 20 mins. The gap between two bouts in alpha male ranged from 2 to 65 mins (mean=20.4 mins) while in case of second male 1 to 4 mins (mean=2.5 mins). On a subsequent day, the alpha male had 16 copulation bouts within a span of 30 mins. this time the inter-bout gap was 1 to 4 mins (mean= 1.9 mins). After that he refused twice despite presentation by the female.

The thrusts of the second male were relatively slower and gentler than the alpha male. After each copulation, the male in most cases uttered *khek-khek* or *ghek-ghek* or *agh-agh* or *kheh-kheh* (just after dismounting). During 42 copulations, the male uttered these on 15 occasions. Post-copulation grooming was observed on 21 occasions in 42 copulation bouts. Females were mostly silent except for one young female that made low scream. While mounting, the males may hold the thigh or waist of the female by one or

both arms. The male also remains completely lifted while copulating as his legs hold those of the females. All the copulation bouts in Bherjan forests were observed in trees, at height ranged from 5 to 23 m. In Borajan, copulation on the ground was also observed.

Despite best efforts the exact gestation period could not be found as the two pregnant females, which were under observation remained elusive for a few days when the young ones were delivered but gave a probable range of 171-180 days.

Ranging behaviour

Northern Pig-tailed Macaques made no effort to defend their home ranges. The overlapping of home ranges and tolerating other groups at close range also indicates the same. The home ranges of Northern Pig-tailed Macaque groups ranged between 83 and 347 ha; the home ranges overlapped by 25 to 48%. In Bherjan forests, the home ranges covered 83 (Western Group) and 101 ha (Eastern Group); the home ranges overlapped by 39 to 48%. In the home range of the western group, around 14% was outside the reserved forest, mainly in Chandmari Tea Estate. In case of the eastern group, around 35% was outside the reserved forest in Athelbari and Dhelakhat Tea Estates (Fig. 4). In Borajan forest, it was about 298 ha (Northern Group) and 347 ha (Southern Group) in 1992-94; home ranges overlapped by 25 to 29%. In the heavily degraded Podumoni forest, it was 150 ha. In Patharia Hill Reserved Forest, the partial home range of a group inside India was >110 ha the remaining being inside Bangladesh. The border fencing has disturbed their movement; however, they move across through select routes, either along rivulets through ground or through trees having canopy links.

The day range length varied between 690 and 2,240 m. The day range of the western group in Bherjan was between 690 and 1,400 m, that of eastern group between 830 and 1,850 m, southern group in Borajan between 780 and 2,240 m and northern group 750 and 2,190 m. The partial day range of a group in Nambor was >1,500 m, in Patharia Hill >900 m, and Dhansiri >2,200 m. Fast travelling of 160 m in 12 mins to slow one, 205 m in 70 mins were observed. A lone male not attached to any group had travelled >500 m in 45 mins in Nambor.

DISCUSSION

So far, this is the first comprehensive study on the ecology and behaviour of the Northern Pig-tailed Macaque *M.n. leonina*. Although this paper is the first such detailed account, its elusiveness and poor visibility had its sway by wasting invaluable time in the field. Earlier observers had also commented similarly (Bernstein 1967; Caldecott 1986).

Although a dweller of dense forest, wherever degradation took place it adapted itself to a great extent (e.g., Podumoni forests). It also haunts tea plantations and vicinity of human settlements (Choudhury 2003a). Crop raids are rare unlike its southern counterpart (Crockett and Wilson 1980). The Northern Pig-tailed Macaque is mostly arboreal in dense forest although they do not hesitate to come down to the ground for crossing clearings and also for foraging, especially in degraded areas. The Southern Pig-tails were largely terrestrial (Cawthon Lang 2005). McCann (1933) also mentioned that it is more arboreal. In case of *leonina*, most of the longer duration terrestrial activity were found to be human induced, i.e., raiding crops and feeding on sugarcane on the highway or crossing clear-felled areas. As a rule, the Northern Pig-tailed Macaque is not very shy, however, in areas where it is hunted for food, it was extremely so.

According to Bernstein (1967) and Medway (1969), when in flight from humans, the Southern Pig-tailed Macaque descends to the ground and flees, but in case of *leonina*, their flight was through trees, either canopy or other layers. Even when on the ground, *leonina* may flee through forest floor or climb trees and flee.

The daily time budget showed rest including roosting (till dusk) accounted for about 45% of their diurnal time. It should be noted that they take up roosting position well before dusk and hence, the proportion of 'inactive' time increases.

Female copulating with more than one male as well as subadults as has been found in *leonina* was also observed in the Southern Pig-tails by other observer (Oi 1996). Their locomotion is somewhat like the Southern Pig-tailed females, but they were not seen to lead the movement. In fact, alpha male was found to take lead at least in one of the intensively studied groups. Elsewhere, during sporadic observations, it was the alpha male that was ahead of others.

The dominance of fruits in diet was conspicuous (hence, frugivorous); however, it may not be out of the way to call the Northern Pig-tailed Macaque an "omnivore" as it takes innumerable small animal matters, most of which could not be identified, and an array of vegetables, gums and a bit of earth. Corner (1941) and Bernstein (1967) also listed the Pig-tailed Macaque as omnivorous. The dominance of fruit in the Pig-tailed Macaque's diet was evident in all the earlier studies, although all were on nominate subspecies (Fooden 1971; Crockett and Wilson 1980; Caldecott 1986). Some tree species play a particularly important role in Pig-tailed Macaque ecology, by providing a major component of food supply in certain seasons, e.g., *Anthocephalus cadamba* (fruit; in September, October, November, 15-20% of the observed feeding time was spent on this), *Sapium baccatum* (fruit; in August, September, October, 25-30%), *Artocarpus chaplasha*

(fruit; in June and July, 35%) and *Castanopsis indica* (fruit; in September, October, 15-20%). In two other interesting cases, which may not be applicable for most of the normal forest groups, sugarcane (stem; in February and March, 42% of the feeding time of the study groups was spent on this) and fallen paddy (grain or seed; in January, 65% of the feeding time was spent on this) formed major diet for certain periods.

According to McClure (1964) and Medway (1969, 1970), the group size in disturbed forests in Peninsular Malaysia was 3-15. Apparently, '3' was not a group but a splinter unit. Fooden (1971) found groups of 12-40 animals. The present study found that the mean of typical groups was 23.3 (range was 16-33). The mean of at least another 15 groups was also >20 where exact number and composition could not be counted. It appears that 20-33 is the ideal range (n=21). Tilson (1982) found 26 in a group at Hollongapar.

The 16 member group was from Podumoni forests, where three-fourth of the forests was in a degraded state and a few monkeys were reportedly killed by village dogs and leopards. The groups of 50-150 Northern Pig-tailed Macaques in Vietnam (Le Xuan Canh *et al.* 1997) and elsewhere, including Khao Yai National Park, Thailand (Duckworth *et al.* 1999), were in all probability of two or more groups feeding/foraging together. This researcher had observed two groups in Khao Yai where he encountered two groups with 25-35 animals. These groups often come closer (looked like a single group) looking for food when visitors stop their vehicles although located deep inside the Park with no opportunistic hunting. In Bherjan, Borajan and Nambor forests, consisting respectively of 59, 43 and 43 macaques were at the end of the day found to be six different groups having overlapping home ranges. Similar temporary 'congregation' was also observed in case of Assamese macaques, putting a casual observer into confusion.

The sex ratio was biased toward females. Females comprised of the major share of any group, 39.9% were adult females (n=7) in this study, while in case of Southern Pig-tails it was 30.4% (n=3) (Oi 1990).

Contact between members within a group or with other groups was largely peaceful, a feature also observed in Southern Pig-tails (Bernstein 1967).

The information on the home range and day range of *leonina* was poorly known prior to this study. It was 83-347 ha against 60-828 ha in Southern Pig-tails. In Nambor and Upper Dihing, the home range could be more than 400 ha (details could not be worked out) while in the colder subtropical forests of Nagaland, it could be much more. The overlapping in this study was up to 48%, which is almost similar to the 50% of southern pigtails (Sponsel *et al.* 2002). The day range length in present study varied between

690 and 2,240 m, which is also not much different from the Southern Pig-tail's 825 and 2,964 m (Caldecott 1986). Weather conditions and seasonal fruit availability had influenced the day ranges to a great extent. With easy food supplements available in large quantity at a fixed place such as paddy (in Borajan) and sugarcane left overs (in Nambor), the day ranges were shorter. During monsoon, often heavy shower also affected the day range to be shorter (the adults look for cover of dense foliage where they sit for quite sometime). In degraded forest, where the fruiting trees were located far apart, the day range increases significantly (e.g., Borajan forests and Patharia Hills).

McCann (1933) stated that the Northern Pig-tailed Macaque probably breeds in April and May, judging from the condition of embryos. Fooden (1971) found lactating and pregnant females in February (early pregnancy) and April (late pregnancy) in western Thailand. According to Crockett and Wilson (1980) and Rowe (1996), Southern Pig-tailed Macaques are not seasonal breeders and mating occurs year-round though there is a slight peak from January to May. The present study on *leonina* shows that several females in estrous were observed from August to December with a few till February while newborns were seen from mid January to May (few in June also). It could be inferred that climate, especially rainfall might have a role in case of *leonina*, which seems to have a marked winter-spring breeding season. This is contrary to the year-round breeding of southern subspecies.

Blanford (1888-91) believed that the gestation period was 210 days. Bernstein (in Roonwal and Mohnot 1977) stated that it is 175 days while Maestriperi (2002) has put it as 170 days. In captivity, it was 162-186 days (Kuehn *et al.* 1965) and 167-179 (Tokuda *et al.* 1968). The present study, although could not fix any day, but confirmed a probable range of 171-180 days (n=2).

Information on mounting in the wild of *leonina* has also been dealt with in details for the first time. Captive macaques were observed since long (Tokuda *et al.* 1968). They observed mounts that lasted for 2-18 seconds (in this study, it was 2-16 seconds); the mean interval between mounts was about 3 mins (in this study, it was variable greatly between individuals; 20.4 mins in alpha male while in case of second male 2.5 mins). The reason seemed to be that the alpha male is relaxed and it carried on copulation bouts at his will and often leisurely (once after a gap of 65 mins) but the second male was in a hurry. It had mounted only when the alpha male was away resting. The mean of pelvic thrusts per mount was recorded as 13 (in this study, it was 10). Oi (1996) and Gouzoules *et al.* (1998) found that the percentage of copulations followed by calls was 98.79% and 45% in two different studies of Pig-tailed Macaques. In this study, it was

36% in case of male only while females were mostly silent (only 2.5%), i.e., no post-copulatory vocalizations. Maestripereri and Roney (2005) put forth one of the hypothesis that copulation calls reflect an orgasm-like reaction.

In Khao Yai National Park, Thailand, a few groups have become habituated and a major part of their diet comes from biscuits, fruits, etc., offered by tourists. Although these groups (at least two groups were observed in July 2006) are deep inside the Park, somehow they developed this habit and are now depending upon it substantially. Despite habitat fragmentation and venturing near human habitations, the Pig-tailed Macaques in Assam and elsewhere in north-east India did not develop this habit although there are Rhesus *Macaca mulatta* and Assamese macaques doing this in some temples and in a few roadside localities (northern Bengal).

The forests of Bherjan, Borajan, Podumini, Hollongapar, Upper Dihing (west block), and Nambor, which were recommended for protected area status after this study (Choudhury 1989, 1995b, 1996c) have been declared as wildlife sanctuaries by the Government of Assam in 1997 (Hollongapar as Hollongapar Gibbon Sanctuary), 1999 (Bherjan, Borajan and Podumini as Bherjan-Borajan-Podumini Wildlife Sanctuary) and 2004 (part of Upper Dihing as Dihing Patkai Wildlife Sanctuary).

Habitat loss and fragmentation due to felling, *jhum* cultivation and expansion of agriculture, and hunting for meat are the main threats to *leonina* in its range in India (Choudhury 2003a). It is protected under Schedule II (part I) of The Wildlife (Protection) Act of India while IUCN has listed it as Vulnerable (IUCN 2004). At least 30 protected areas in north-

east India (12 in Assam) have known population of *leonina*. Adequate protection of existing habitat, declaration of some key sites as protected (Dhansiri in Assam, and Narpuh in Meghalaya); and check on felling and *jhum* cultivation are the need of the hour.

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Appendix 1: Food plants and items eaten by Pig-tailed macaques (across groups and study areas)

| Species (Family) | Leaves, leaf buds | Leaf petioles | Fruits | Flowers, Buds | Seeds | Shoots | Others |
|--|----------------------|---------------|--------|------------------|-------|--------|-----------------|
| <i>Aerides</i> sp. (Orchidaceae) | | | | | | | +Stem / root |
| <i>Albizzia lucidor</i> (Mimosaceae) | | | | | + | | |
| <i>Amblyanthus</i> sp. (Myrsinaceae) | | | + | | | | |
| <i>Amoora wallichii</i> (Meliaceae) | | | + | | | | |
| <i>Anthocephalus chinensis / cadamba</i> (Rubiaceae) | | | + | | | | |
| <i>Ardisia</i> sp. 1 (Myrsineceae) | | | + | | | | |
| <i>Ardisia</i> sp. 2 (Myrsineceae) | | | + | | | | |
| <i>Artocarpus chaplasha</i> (Moraceae) | + | | + | | | | |
| <i>Artocarpus lakoocha</i> (Moraceae) | | | + | | | | |
| <i>Baccaurea ramiflora</i> (Syn. <i>sapida</i>) (Euphorbiaceae) | | | + | | | | |
| <i>Bambusa tulda</i> (Bambusaceae) | | + | | | | + | |
| <i>Bambusa balcooa</i> (Bambusaceae) | | + | | | | + | |
| <i>Bauhinia purpurea</i> (Caesalpinaceae) | | | | | + | | |
| <i>Bauhinia variegata</i> (Caesalpinaceae) | | | | | + | | |
| <i>Bischofia javanica</i> (Euphorbiaceae) | | | + | | | | |
| <i>Bombax ceiba</i> (Bombasaceae) | | | | + | | | |
| <i>Carica papaya</i> (Caricaceae) | | | + | | | | |
| <i>Castanopsis indica</i> (Fagaceae) | | | + | | | | |
| <i>Cinnamomum glanduliferum</i> (Lauraceae) | | | + | | | | |
| <i>Cinnamomum bejolghota</i> (Syn. <i>C. obtusifolia</i>) (Lauraceae) | | | + | | | | |
| <i>Citrus reticulate</i> (Rutaceae) | | | + | | | | |
| <i>Crateva magna</i> var. <i>magna</i> (Syn. <i>Crateva nurvala</i>) (Capparidaceae) | | | | + | | | |
| <i>Croton joufra</i> (Euphorbiaceae) | | | | | + | | |
| <i>Dendrocalamus hamiltonii</i> (Bambusaceae) | | + | | | | + | |
| <i>Dillenia indica</i> (Dilleniaceae) | + bud | | + | | | | |
| <i>Dillenia scabrella</i> (Dilleniaceae) | | | + | | | | |
| <i>Dysoxylum gobara</i> (Syn. <i>D. procerum</i>) (Meliaceae) | | | | + | | | |
| <i>Ficus benjamina</i> (Urticaceae) | | | + | | | | |
| <i>Ficus hispida</i> (Moraceae) | | | + | | | | |
| <i>Ficus glaberrima</i> (Urticaceae) | | | + | | | | |
| <i>Ficus hirta</i> (Urticaceae) | + | | + | | | | |
| <i>Ficus mysorensis</i> (Urticaceae) | | | + | | | | |
| <i>Ficus nervosa</i> (Urticaceae) | | | + | | | | |
| <i>Ficus religiosa</i> (Urticaceae) | | | + | | | | |
| <i>Ficus rhododendrifolia</i> (Urticaceae) | | | + | | | | |
| <i>Ficus rostrata</i> (Syn. <i>sinuata</i>) (Urticaceae) | | | + | | | | |
| <i>Ficus</i> sp. 1 (Moraceae) | | | + | | | | |
| <i>Ficus</i> sp. 2 (Moraceae) | | | + | | | | |
| <i>Garcinia morella</i> (Guttiferae) | | | + | | | | |
| <i>Garuga pinnata</i> (Burseraceae) | + | | + | | | | |
| <i>Gmelina arborea</i> (Verbenaceae) | | | + | + | + | | |
| <i>Gynocardia odorata</i> (Flacourtiaceae/Bixaceae) | | | + | | | | |
| <i>Hoya parasitica</i> (Asclepiadaceae) | | | + | + | | | |
| <i>Ipomoea</i> sp. (Convolvulaceae) | + | | | | | | |
| <i>Jasminum dispernum</i> (Oleaceae) | + | | | | | | |
| <i>Lagerstroemia flos-reginae</i> (Syn. <i>speciosa</i>) (Lythraceae) | | | + | | | | |
| <i>Ligustum</i> sp. (Oliaceae) | | | | + | | | |
| <i>Litsea polyantha</i> (Lauraceae) | | | | | + | | |
| <i>Macrosolen cochinchinensis</i> (Loranthaceae) | | | + | | | | |
| <i>Mallotus philippensis</i> (Euphorbiaceae) | | | | | + | | |

Appendix 1: Food plants and items eaten by Pig-tailed macaques (across groups and study areas) (*contd.*)

| Species (Family) | Leaves, leaf buds | Leaf petioles | Fruits | Flowers, Buds | Seeds | Shoots | Others |
|--|----------------------|---------------|--------|------------------|-------|--------|-----------------|
| <i>Malvastrum</i> sp. (Malvaceae) | | | | + | | | |
| <i>Mangifera sylvatica</i> (Anacardiaceae) | | | | + | | | |
| <i>Mangifera indica</i> (Anacardiaceae) | | | | + | | | |
| <i>Melocanna baccifera</i> (Syn. <i>bambusoides</i>) (Bambusaceae) | | + | | | | + | |
| <i>Mesua ferrea</i> (Clusiaceae) | + | | | | | | |
| <i>Mezoneurum cucullatum</i> (Leguminaceae) | | | | + | | | |
| <i>Miliusa vetulina</i> (Annonaceae) | | | + | | | | |
| <i>Musa</i> spp. (Musaceae) | | | + | + | | | |
| <i>Nephelium litchi</i> (Sapindaceae) | | | + | | | | |
| <i>Oryza sativa</i> (Oryzeae) | | | | | + | | |
| <i>Pelathanthera</i> sp. (Orchidaceae) | | | | | | | +Stem / root |
| <i>Picrasma</i> sp. (Simaroubaceae) | + | | | | | | |
| <i>Premna bengalensis</i> (Verbanaceae) | | | + | | | | |
| <i>Pseudostachyum polymorphism</i> (Bambusaceae) | | + | | | | + | |
| <i>Quercus listerni</i> (Fagaceae) | + | | | | | | |
| <i>Saccharum officinarum</i> (Poaceae) | | | | | | | Stem |
| <i>Sapium baccatum</i> (Euphorbiaceae) | | | + | | | | |
| <i>Schizostachyum dulloa</i> (Poaceae) | | | | | | + | |
| <i>Smitinandia</i> sp. (Orchidaceae) | | | | | | | +Stem / root |
| <i>Spatholobus roxburghii</i> (Fabaceae) | | | | + | | | |
| <i>Spondias pinnata</i> (Syn. <i>mangifera</i>) (Anacardiaceae) | | | + | + | | | |
| <i>Sterculia villosa</i> (Sterculiaceae) | + (tender) | | | + | | | |
| <i>Symplocos spicata</i> (Symplocosaceae) | + | | | | | | |
| <i>Terminalia chebula</i> (Combretaceae) | | | + | | | | |
| <i>Terminalia belerica</i> (Combretaceae) | | | + | | | | |
| <i>Uncifera</i> sp. (Orchidaceae) | | | | | | | +Stem / root |
| <i>Wrightia tomentosa</i> (Apocynaceae) | + | | | | | | |
| <i>Zea mays</i> (Poaceae) | | | | | + | | |

'+' - food items consumed

'?' - ambiguous whether consumed or not

[Synonyms are important as many authorities still use earlier names.

Two *Ficus* spp. could not be identified but were two distinct species and hence, listed to show the diversity]

